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ABSTRACT

A study examined the effects of adjunct questions on learning. Subjects, 93 male and 78 female sixth-grade students from two junior high schools in small towns located in a largely agricultural region in the Midwest and whose mean grade equivalency on the reading sub-test of the Stanford Achievement Test was 10.2, were monitored by video cameras as they studied expository text in anticipation of a test on the following day. Subjects were divided into four groups based on the reading strategy used: (1) read-only (adjunct questions not provided); (2) look-back (adjunct questions provided and text not removed); (3) no-look-back (text removed but adjunct questions provided); and (4) same-time (questions and text received by subjects at the same time with no conditions stipulated). Results indicated a strong direct effect and a modest indirect effect of answering questions, with the no-look-back strategy group performing better on new criterion questions than the read-only, look-back, or same-time groups. Results also indicated a forward indirect effect in that on the final text segment during which no questions were given, the no-look-back strategy was better than the look-back, same-time, and read-only strategies. It is concluded that when students read and answer questions they are most likely to learn what they are questioned about, but the overall most efficient use of the students' reading time is to read the entire passage before answering questions because this increases the likelihood that more information will be learned. (Four tables of data are included; 30 references are attached.) (Author/RS)

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HOW SIXTH GRADERS READ EXPOSITORY TEXT TO ANSWER QUESTIONS AND HOW THAT AFFECTS THEIR LEARNING

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HOW SIXTH GRADERS READ EXPOSITORY TEXT TO ANSWER QUESTIONS AND HOW THAT AFFECTS THEIR LEARNING

Abstract

Sixth graders were monitored by video cameras as they studied expository text in anticipation of a test on the following day. Some students only read the four text passages while others answered questions under various conditions. After reading the passage once, one group was not allowed to look back while answering the questions while another group was allowed to do so. A final group received the questions and the text at the same time and opted to use the questions in whatever way they wished. Results showed that there was a strong direct effect and a modest indirect effect of answering questions, in that the no look back strategy group performed better on new criterion questions than the groups that only read the text or simply searched for answers to the adjunct questions. In addition, there was a forward indirect effect in that on the final text segment during which no questions were given, the no look back strategy was better than the look back, search and read only strategies. Conclusions are that when students read and answer questions, they are most likely to learn what they are questioned about, but the overall most efficient use of the students' reading time is to read is to read the entire passage before answering the questions because some information other than that being questioned has an improved likelihood of being learned.

The effects of adjunct questions on learning have been studied at least since Washburne (1929), and a considerable body of literature has developed detailing just what effects are likely to occur under which circumstances and theorizing about why such effects occur (Anderson & Biddle, 1975; Hamaker, 1984; Andre, 1987). Still, questions remain.

Some researchers (Gustafson & Toole, 1970; Duchastel & Nungester, 1984) hypothesize that certain effects noted in earlier research will disappear under the "ecologically valid" condition which permits students to physically review or look back into the text while answering their questions. Some have found the effects for younger readers to be different from those established in the literature for older readers (Swenson & Kulhavy, 1974; Robinson, 1975; Rowls, 1975; Memory, 1981, 1983). Others have questioned (Carver, 1972) or investigated (Reynolds & Anderson, 1982) the relationship between the time spent interacting with the text and the learning that results.

Many practical issues still need to be resolved, issues relevant to the classroom teacher and the student as well as to the theorist. What is the best sequence of study for a reader to follow? Should a student read the text through and answer questions from memory, read the text and then use it to answer questions, or read each question one at a time and search the text for answers? Which sequence will result in better memory for questioned material and which for non-questioned material?

A further question this study asks is whether the same effects observed for mature readers will be observed for sixth graders. What sequence of study will most sixth graders follow when given the choice? Which will make the most efficient use of time and result in the best ratio of total learning to time spent reading?

The corpus of adjunct questions studies offers support for several different effects on learning. The strength of these effects can vary with question placement and other study conditions. Essentially, they can be summarized under three categories: direct effect, indirect effect, and indirect forward effect.

Direct Effect

The direct effect of adjunct questions is well supported in the literature (Rothkopf, 1966; Rickards, 1979; Hamaker, 1984). The direct effect refers to the learning of directly questioned material. Direct effects are

robust regardless of question placement, before or after the text (Anderson & Biddle, 1975; Hamaker, 1984; Andre, 1987).

This effect is even stronger when students are allowed access to the text and when they make an overt response to the questions (Hamaker, 1984). Arguable, these effects result from the selective attention that readers devote to finding answers to their questions. Britton, Piha, Davis, and Wehausen (1978) have found that students are more deeply engaged while reading question relevant text; Reynolds, Standiford, and Anderson (1979) have found that students spend more time on question relevant text; Reynolds and Anderson (1982) have found that students spend more time and attention on question relevant text. This selective attention, with the more intensive processing attendant to it, contributes to a better memory for the questioned information.

The direct effect is also noted when the students are not permitted to look back in the text. Anderson and Biddle (1975) propose that "an adjunct question sets the occasion for mental review and further cognitive processing of text information. When the quiz question happens to make contact with temporarily-stored information, it is theorized that this information will be transferred into long-term, semantic memory."

Indirect Effect

The indirect effect of adjunct questions has not been consistently supported in the research literature. An indirect effect refers to the learning of textual information not specifically referred to by adjunct questions. Some researchers (Gustafson & Toole, 1970; Duchastel & Nungester, 1984) have held that it is only when questions are placed after a reading, and when the previously read text cannot be reread to find the answers, that an indirect effect can be expected. Others have found no indirect effect for younger readers (Robinson, 1975; Rowls, 1975) under any circumstances.

Anderson and Biddle (1975) conclude that questions presented before material to be read have a positive direct effect and a negative indirect effect; that is, students who receive prequestions are more likely than students without questions to learn questioned material, but less likely to learn material not covered by the questions. They also conclude that questions presented after textual material have both a positive direct and indirect effect.

The indirect effect of postquestions (sometimes referred to as an indirect backward effect) has been attributed to a backward mental review of material just read (Frase, 1967; Anderson & Biddle, 1975; Rickards, 1979). In such a review, all textual information that has just been read and temporarily stored is non-selectively reconsidered. Such a mental review results in heightened memory for questioned and non-questioned information alike.

The indirect effect of postquestions has not been consistently found in all studies (Hiller, 1974; Robinson, 1975; Rowls, 1975). Studies by Gustafson and Toole (1970) and Duchastel and Nungester (1984) found no indirect effect when lookbacks were allowed. Under such conditions, any temporarily stored information, instead of being subjected to a mental review, might be cleared for the task at hand, finding specific answers to specific questions. Such focusing on the task does not encourage a reader to mentally consider the information that has just been read, but rather to search for specific answers, checking text only to determine whether it contains relevant information.

Indirect Forward Effect

The indirect forward effect (sometimes called a general forward effect) of adjunct questions refers to a carrying forward of the same kind of processing activity previously being undertaken in response to adjunct questions, as a sort of forward momentum. Students who have been questioned directly after reading a segment of text for several times in succession can be expected to read subsequent segments of text more carefully. If they have been questioned about names, for example, after each segment, they would be expected to pay closer attention to names in subsequent segments. This is sometimes referred to as a specific forward effect (Rickards, 1979). If they had been given general questions after each segment, any resultant effect on learning would be referred to as an indirect forward effect.

The indirect forward effect is arguably the result of reader expectations. If a reader expects to be quizzed over what is to be read, and previous textual segments have led the reader to believe that would be the case, then that reader would be expected to read the ensuing textual segment more carefully in anticipation of such questions. If a reader expects a quiz at the end of a textual segment, but knows that he or she will be allowed to look back in the text, then the reader would have no reason to read with any particular attention. Therefore, the indirect forward effect should be expected only when the reader has

been previously questioned without having the benefit of looking back in the text, and has reason to expect another such quiz at the end of the next segment of text. Reynolds and Anderson (1982) attribute this effect to "non-selective attention."

Question Level

A number of question taxonomies exist to describe question types, their relationship to the reader and the text, and the kind of processing they induce (Anderson, 1970, 1972; Pearson & Johnson, 1978; Andre, 1979; Fredrickson, 1981). The jury is still out for a definitive conclusion on how question types compare with one another on the type and degree of learning each induces and how this varies with position. Hamaker (1984), in an extensive review of the literature, found a generably favorable effect size for higher order questions compared with factual questions. Andre's (1987) review dissented with his findings. Also, the literature suggests that effects found for one type of question in one position relative to the text might not be the same for another type of question in that position. For example, factual prequestions might inhibit indirect learning while higher order prequestions might facilitate indirect learning. However, research findings are mixed on such questions (Andre, 1979; Hamilton, 1985; Andre, 1987).

METHOD

Subjects

Subjects were 171 sixth graders drawn from two junior high schools in small towns located in a largely agricultural region in the Midwest. Of these, 93 were male and 78 were female. Their reading level, as measured by the reading comprehension sub-test of the Stanford Achievement Test (1986), ranged from third grade to post high school. Mean grade equivalency on this test was 10.2 at a time when their actual grade in school was 6.7.

Materials

A four-lesson, 2400-word chapter entitled "The Celts" taken from a sixth grade textbook *Social Studies* (Scott, Foresman, 1979, pp. 340-347) was used as the experimental text. This textbook was not currently used in either of the schools. Although the subject matter was expected to be relatively unfamiliar to most sixth graders, the criterion tests were administered to a class of seventh graders from one of the two schools

to determine that the content was in fact unfamiliar to most students of middle school age. The text was prepared for videotaping by placing each paragraph and a large page number on a separate page.

Adjunct Questions

Each adjunct question was printed on a separate page. A large identifying number appeared on each page as well.

Textually Explicit (TE) Questions

One set of textually explicit questions was constructed according to the following guidelines: the answer to each question must be explicitly stated in the text and included within one sentence (C.F., Pearson & Johnson, 1978). They were then placed in the rank order of their relative structural importance in the text by five independent judges.

The six questions chosen to be most important to each of the three lessons were then paired according to the order of their importance, with questions 1 and 2 being on the same tier, 3 and 4 being on the same tier, and so on. They were then randomly assigned to either question set A or question set B. For example, question set A for lesson one consists of questions 1, 4 and 5. Questions were counterbalanced in this way so that each student would have three adjunct questions for each of the first three lessons, with all six questions again appearing on the TE criterion test. Questions that were adjunct questions for the set A group, and therefore repeated on the TE test, were new items for the set B group, and vice versa. Performance on the nine new items, i.e., three questions for each of the first three lessons, on the TE test was seen as a measure of indirect learning, and performance on the nine repeated items on the TE test was seen as a measure of direct learning.

Subjects receiving textually explicit questions received three questions for each of the first three lessons, and no questions for the fourth lesson. Six questions from Lesson Four that appeared on the TE criterion test were seen as a measure of an indirect forward effect.

Textually Implicit (TI) Questions

One textually implicit "inferential/summary" question was written for each lesson. By definition, a textually implicit question requires information from two or more sentences in the text to answer it (Pearson & Johnson, 1978). These questions were intended to be broad enough to cover most of the textual material

in each lesson. Two questions were compare and contrast questions, and a third asked readers to judge the importance of an important figure in the tribe, the druid. One of these questions, that for Lesson Two, was repeated as a criterion question. Subjects received no question for Lesson Four. An inferential/summary question for Lesson Four was given the next day as a criterion measure for a measure of an indirect forward effect.

Criterion Tests

The first part of the criterion test was the same TI question that subjects in the TI groups saw as an adjunct question for Lesson Two, and was considered to be a test of direct effect for subjects in the TI groups, and a test of indirect effect for subjects in the TE groups. The second part of the criterion test was a TI question covering the material covered in Lesson Four of the chapter, and was considered to be a test of an indirect forward effect. There was no TI question from Lesson One or Three on the Criterion test.

The third part of the criterion test was a 24-question short answer TE test which consisted of six items from each lesson, including Lesson Four. Items were counterbalanced so that for subjects in the TE groups, half of all the items were new and half were repeated. In that way a measure of both direct and indirect effect could be obtained for subjects in both question sets, without a bias for either question set. All the TE items were new items for subjects in the TI group and subjects in the read only group, and thus a measure of indirect effect for those subjects. The six TE items from Lesson Four were new for all subjects and were considered as a measure of an indirect forward effect.

Experimental Treatments and Experimental Design

Subjects were divided into two ability groups according to their scores on the reading comprehension sub-test of the Stanford Achievement Test (1986) which was administered that semester in both schools. The subjects from each group, those above and those below the median (a raw score of 48/60 or a grade equivalency of 10.5) were randomly assigned to treatment groups. They were then randomly assigned to receive either TE or TI adjunct questions. Subjects in the below average group ranged from a score of 17 correct answers out of a total of 60 questions on the test (GE = 3.2) to 47/60 (GE = 10.0), while subjects in the above average group ranged from 48/60 (GE = 10.5) to 60/60 (GE = Post High School).

Assignment Conditions

Lookbacks-Not-Allowed. Subjects in this group read each lesson first, then were given a set of adjunct questions (either TE or TI) when they were finished reading. The text was removed before they were given their questions so that lookbacks were not possible. The two levels of this condition are referred to as the Lookbacks-Not-Allowed TE and TI groups (LBNA-TE and LBNA-TI).

Lookbacks-Allowed. Subjects in this group read each lesson first, then were given a set of adjunct questions (either TE or TI). The text was not removed when they were given their post-questions, so that lookbacks were possible. The two levels of this condition are referred to as the Lookbacks-Allowed TE and TI groups (LBA-TE and LBA-TI).

Same-Time. Subjects in this group received both their lesson and adjunct question(s) at the same time. The decision of whether to read the question or the lesson first was left to each student without comment by the researchers. The two levels of this condition are referred to as the Same-Time TE and TI groups (ST-TE and ST-TI).

Read-Only. Subjects in this group received the lesson to read but no adjunct questions. This condition is referred to as the Read-Only group (RO).

Procedure

Data Collection

In order to determine which procedure each student actually followed, each subject was videotaped individually as (s)he read each lesson and responded to each adjunct question. The video camera was positioned in front of subjects so that each page was in view as they read it. A clock showing real time appeared at the bottom of the video screen to provide a record of how much time was spent on each paragraph and on each question. Subjects took their criterion tests 24 hours after they had read the text and answered adjunct questions, if any.

Data Coding and Scoring

Reassignment of Subjects into Processing Groups

Subjects were divided into the following processing groups according to the strategies they *actually* used to read the text and answer their questions. The analyses which follow will use these two major groupings: assignment condition and processing group. Criteria for dividing subjects into processing groups follow:

No Lookbacks. Subjects in the No Lookbacks processing group are characterized as follows: These subjects read the entire lesson first, and then answered their questions entirely from memory without looking back into the text. This includes all subjects in the Lookbacks-Not-Allowed assignment condition, as well as some subjects in the Lookbacks-Allowed and Same-Time assignment conditions. The two levels of this condition are referred to as the No-Lookbacks TE and TI processing groups (NLTE and TI).

Lookbacks. Subjects in the Lookbacks processing group are characterized as follows: they read the entire lesson, then read their question(s) and searched for answer(s) one at a time. This included some subjects in the Lookbacks-Allowed and Same-Time conditions. The two levels of this condition are referred to as the Lookbacks TE and TI processing groups (LBTE and TI).

Search. Subjects in the Search processing group are characterized as follows: they did not read the entire lesson through first, but rather read each question and searched for answers to each question. These subjects came exclusively from the Same-Time assignment condition.

The two levels of this condition are referred to as the Search TE and TI processing groups (STE and STI).

Read-Only. This group included all subjects assigned into the Read-Only assignment condition.

Procedure for Coding Time Measures from Video Observations

The following time values were coded for each subject:

Total time spent reading. This was the total time subjects spent reading paragraphs in the lessons. It does not include time spent writing answers and does not include time spent reading while writing. It includes time spent reading before the question and time spent reading after the question.

Time taken to find the target paragraph. This was the time subjects took, after reading their question, to find the target paragraph--the paragraph which had the information necessary to answer the adjunct question.

As a test of inter-rater reliability, an independent scorer coded a random sample of 17 subjects using the above system. These time values were found to correlate together with a Pearson's Product Moment Coefficient of .94.

Scoring Answers to Criterion Test Questions

TE questions. To analyze answers to criterion TE questions, completeness and correctness of response was determined *a priori* and answers were judged accordingly. One point was awarded to each answer judged to include the complete answer. Partial credit was awarded for incomplete answers. The correlation coefficient between the scoring of two raters as .889.

TI questions. Idea units relevant to answering the criterion TI questions were determined *a priori*. This list of idea units was used to score idea units that appeared on responses to the inferential/summary criterion question. On answers to inferential/summary questions, one point was awarded to each correct and complete idea unit contained in each answer. The inter-rater reliability correlation between two independent raters was .836.

Statistical Analyses

Analyses of dependent measures. Because subjects would require at least one lesson to adjust their procedures to their reading circumstances, only data from Lessons Two, Three, and Four were used in the analyses. Lesson One was considered a practice or orientation lesson.

Repeated items on the criterial TE test that were based on questions taken from textual information in Lessons Two and Three served as a measure of the direct effect of TE questions. Only subjects who received TE adjunct questions could be said to have experienced a direct effect of those questions.

New items on the criterial TE test that were based on questions taken from textual information in Lessons Two and Three served as a measure of the indirect effect of TE questions for Lessons Two and Three. For subjects who had received a TI adjunct question or no adjunct question, all TE criterial questions from Lessons Two and Three were new ones, and thus served as a measure of an indirect effect.

All criterial items from Lesson Four were new to all subjects. Therefore, the TE items on the criterial test that related to Lesson Four served as a measure of an indirect or general forward effect.

Of the two TI questions asked on the criterial test, one was a repeated question from Lesson Two, which served as a measure of direct effect for subjects who had received TI adjunct questions and a measure of indirect effect for subjects who had received TE adjunct questions. The second TI criterial question covered information discussed in Lesson Four, and therefore served as a measure of an indirect or general forward effect.

Because of the unbalanced design, e.g., the RO group had no questions, those interactions which included adjunct question types were not logical. Therefore, all possible higher order interactions and main effects were tested for significance following Wilkinson (1987). According to this method, only significant interactions and main effects were retained and used in the final regression analysis. The dependent measures were repeated TE questions for Lessons Two and Three, new TE questions for Lessons Two and Three, new Lesson Four TE questions, the repeated Lesson Two TI question, the new Lesson Four TI question, and the four efficiency measures discussed below. The independent measures were reading ability, lesson, adjunct question type, and processing group or assignment condition. Bonferroni post-hoc comparisons (Wilkinson, 1987) were used to test the differences among group means.

Time to target measures were analyzed in a separate analysis to determine the effects of processing groups (Lookbacks and Search) and adjunct question type.

Analysis of reading efficiency. In order to determine which procedure would make the most efficient use of the readers' time, we created a reading efficiency dependent measure. This measure was an index of total learning divided by total time spent reading. Four such measures were created depending on the type of criterial item and the lesson: TE Efficiency for Lessons Two and Three, TE Efficiency for Lesson Four, TI Efficiency for Lessons Two and Three, and TI Efficiency for Lesson Four. TE Efficiency for Lessons Two and Three consisted of the total TE score for Lessons Two and Three (repeated and new items) divided by the total time spent reading Lessons Two and Three. TI Efficiency consisted of the score for the repeated TI question divided by the total time spent reading Lessons Two and Three. TE Efficiency for Lesson Four consisted of the total TE score for Lesson Four divided by the total time spent reading Lesson Four. TI Efficiency for Lesson Four consisted of the score for the TI question from Lesson Four divided by

the total time spent reading Lesson Four. These four dependent measures were then analyzed as described above.

RESULTS

Use of Adjunct Questions: Strategy Selection

Most subjects consistently used the same procedure for each lesson, although there were exceptions. These 16 exceptional subjects, while never changing assignment condition, were reassigned to different processing groups from one lesson to the next.

All but one of the subjects in the Lookbacks-Allowed Condition who had the TE question treatment did look back in the text (see Table 1). Most of the LBA subjects with the TI question treatment looked back. A Chi-square test showed that the proportion of TE subjects in the Lookbacks-Allowed condition who chose to look back versus those who did not look back was significantly greater than the proportion of TI subjects in the Lookbacks-Allowed condition who chose to look back. Chi-squared (1) = 11.53 ($p = .0007$).

[Insert Table 1 about here.]

The most popular choice for subjects in the Same-Time condition was to search for answers, by a slim non-significant margin over the strategy of reading the text first and then looking for answers. There was no significant difference by question treatment (TE or TI) in proportion of strategy chosen by subjects in this assignment condition.

The number of subjects in each assignment varied slightly from lesson to lesson because of either incomplete video data due to electronic failure or incomplete adjunct question or criterion data due to human error.

Learning Outcomes: Repeated Items

Several tests of the direct effects of adjunct questions were available in this study. One test was the difference between the grand mean for all TE subjects on *repeated* criterial items from Lessons Two and Three compared with that on *new* criterial items. The average score on repeated items, 1.44 out of 6, was significantly higher than the average score on new items, .75 out of 6, $F(1,149) = 77.286$, $p < .00001$.

Another test of the direct effect can be seen in a comparison between TE and TI subjects on items which are repeated for TE subjects and new for TI subjects and vice versa. On repeated TE items, TE

subjects significantly outperformed TI subjects [$F(1,332) = 43.141$, $p < .00001$]. On the repeated TI criterion question, TI subjects significantly outperformed TE subjects [$F(1,331) = 8.16$, $p < .005$] as a measure of direct effect. See Table 2 for a comparison of means.

[Insert Table 2 about here.]

Assignment Conditions

Results from the analysis of repeated TE criterion items show that subjects in the Lookbacks-Allowed condition significantly outperformed those in the Lookbacks-Not-Allowed [$F(1,175) = 6.09$, $p = .015$] and the Read-Only [$F(1,175) = 28.32$, $p < .00001$] conditions. Subjects in the Same-Time condition outperformed those in the Lookbacks-Not-Allowed [$F(1,175) = 4.80$, $p = .03$] and Read-Only [$F(1,175) = 28.32$, $p < .00001$] conditions. See Table 2 for a comparison of means.

There was a significant ability by assignment condition interaction, $F(3,183) = 3.53$, $p = .016$. The advantage enjoyed by above-average subjects over below-average subjects was significantly greater for the Lookbacks-Allowed and No-Lookbacks assignment conditions than it was for the Same-Time Condition. In other words, below-average subjects seemed to do better in the Same-Time condition relative to above-average than they did in the other two treatment conditions.

On the repeated TI question, there was no direct effect by assignment condition or significant interactions.

Processing Groups

On TE repeated items, subjects in the Lookbacks Processing Group outperformed those in the No-Lookbacks [$F(1,186) = 7.78$, $p = .006$] and the Read-Only [$F(1,186) = 35.90$, $p < .00001$] groups. Subjects in the Search group outperformed those in the Read-Only [$F(1,186) = 25.44$, $p < .00001$] and the No-Lookbacks [$F(1,186) = 4.09$, $p = .045$] groups. Subjects in the No-Lookbacks group outperformed those in the Read-Only group [$F(1,186) = 12.38$, $p = .0005$]. There were no two-way or three-way interactions by ability, lesson or processing group on repeated TE items. See Table 2 for a comparison of means.

On the repeated TI question, there was no direct effect by processing group or significant interactions.

Learning Outcomes: New Items

Assignment Conditions

On new TE items, subjects in the Lookbacks-Not-Allowed condition only marginally outperformed those in the Same-Time [$F(1,326) = 2.87$, $p = .091$] and the Read-Only [$F(1,326) = 2.83$, $p = .094$]. Subjects in the Lookbacks-Allowed condition significantly outperformed those in the Same-Time [$F(1,326) = 11.27$, $p = .0009$] and Read-Only [$F(1,326) = 8.18$, $p = .0045$] conditions. See Table 2 for a comparison of means.

There were significant assignment condition by question type by ability [$F(3,326) = 7.94$, $p = .00004$] and lesson by ability [$F(1,326) = 4.12$, $p = .04$] interactions. Lower ability Subjects with TE questions in the Lookbacks-Not-Allowed Assignment Condition performed better relative to higher ability subjects with TE questions in that condition than did subjects in the other assignment conditions. In other words, lower ability subjects with TE questions seemed to perform best relative to higher ability subjects in the Lookbacks-Not-Allowed condition.

The ability by lesson interaction shows that on Lesson Two lower ability subjects with TE questions in the Lookbacks-Not-Allowed condition did slightly better than higher ability subjects in that condition. On Lesson Three, however, those same subjects reversed their order, with higher ability subjects outperforming lower ability subjects as would be expected.

On the TI criterion measure, there was no indirect effect by assignment condition.

Processing Groups

On new TE items, subjects in the No-Lookbacks group outperformed those in the Search [$F(1,336 = 7.43$, $p = .007$] and Read-Only [$F(1,336) = 4.53$, $p = .034$] groups. The Lookbacks group significantly outperformed the Search [$F(1,336) = 3.86$, $p = .05$] group and was higher than the Read-Only [$F(1,336) = 2.32$, $p = .129$] group at a level of confidence which approached significance. There were no two-way or three-way interactions by lesson, processing group or question type. See Table 2 for a comparison of means.

On the TI criterion measure, there was no indirect effect by processing group or significant interaction.

Learning Outcomes: Lesson Four

Assignment Conditions (Lesson Four)

There were no significant differences by assignment group.

Processing Groups (Lesson Four)

The situation was different for processing groups. Remember that subjects were assigned into processing groups for Lesson Four according to the strategies they used on Lesson Three. There were no significant effects by processing group or question type on the TI criterion measure, though subjects in the No-Lookbacks group outperformed those in the Search [$F(1,162) = 2.407$, $p = .128$] and the Lookbacks [$F(1,162) = 2.449$, $p = .12$] groups at levels of confidence which approached significance.

On the TE criterion items for Lesson Four, the No-Lookbacks group outperformed the Lookbacks [$F(1,162) = 11.446$, $p < .001$], the Search [$F(1,162) = 5.407$, $p = .021$], and the Read-Only [$F(1,162) = 5.272$, $p = .023$] groups. See Table 2 for a comparison of means.

There were no forward effect interactions by assignment condition or processing group.

Reading Efficiency Measures: Lessons Two and Three Assignment Conditions

Subjects in the Same-Time Assignment Condition scored significantly higher on the *TE efficiency measure* than subjects in the Lookbacks-Not-Allowed [$F(1,331) = 4.75$, $p = .03$] and the Read Only [$F(1,331) = 10.3$, $p = .0015$] assignment conditions. Subjects in the Lookbacks-Allowed condition scored significantly higher than subjects in the Read Only Condition, $F(1,331) = .008$. Subjects who had TE adjunct questions did not score significantly higher on the TE efficiency measure than subjects who had TI adjunct questions. See Table 3 for a comparison of means.

[Insert Table 3 about here.]

There was a significant ability by lesson interaction, $F(1,331) = 8.58$, $p = .004$. High ability subjects as a rule had better TE efficiency scores on Lesson Three than on Lesson Two while low ability subjects did slightly worse or about the same on Lesson Three as on Lesson Two.

There were no differences on the *TI efficiency measure* by assignment condition for Lessons Two and Three. Subjects who had TI adjunct questions scored significantly higher on this measure than subjects who had TE adjunct questions, $F(1,141) = 5.88$, $p = .017$. See Table 3.

Processing Groups

Subjects in the Search Processing Group scored significantly higher on the *TE efficiency measure* than subjects in the No-Lookbacks [$F(1,331) = 11.34$, $p = .0008$], Lookbacks [$F(1,331) = 16.52$,

p = .00006], and Read Only [F(1,331) = 20.57, p < .00001]. Subjects in the No-Lookbacks Processing Group scored significantly higher on this measure than subjects in the Read Only group [F(1,331) = 4.90, p = .028]. Subjects in the Lookbacks Processing Group scored higher on this measure than subjects in the Read Only group at a level which approached significance [F(1,331) = 2.81, p = .095]. Subjects who had TE adjunct questions did not score significantly higher on the TE efficiency measure than subjects who had TI adjunct questions. See Table 3.

There were significant processing group by ability [F(3,331) = 3.14, p = .026] and lesson by ability [F(1,331) = 8.75, p = .003] interactions on the TE efficiency measure. Search subjects with higher ability did much better on TE efficiency than high ability subjects in other processing groups while search subjects with low ability did only marginally better than low ability subjects in other processing groups.

Again, the same interaction that was true by assignment condition was true by processing group. That is, subjects with high ability seemed to score better on TE efficiency for Lesson Three than they did for Lesson Two, while for subjects of low ability scores did not differ by lesson.

Subjects in the Search Processing Group scored significantly higher on the *TI efficiency measure* than subjects in the No-Lookbacks [F(1,165) = 5.45, p = .02], Lookbacks [F(1,165) = 8.36, p = .004), and Read Only [F(1,165) = 3.05, p = .08] processing groups. Subjects who had TI adjunct questions scored significantly higher on this measure than subjects who had TE adjunct questions [F(1,141) = 17.43, p < .00001]. See Table 3.

There was also a significant two-way interaction between question type and processing group [F(2,141) = 8.33, p = .0004]. Subjects in the Lookbacks and Search processing groups with TI questions did better on TI efficiency than subjects in those conditions with TE questions, while for subjects in the No-Lookbacks Processing Group the type of question they had received as adjunct questions did not seem to matter on their TI efficiency scores.

Efficiency Measures: Lesson Four

Assignment Conditions

Subjects in the Lookbacks-Not-Allowed Assignment Condition had marginally higher TE efficiency scores than subjects in the Read Only condition, F(1,161) = 3.56, p = .06.

There were no differences or interactions on the TI efficiency scores by assignment condition for Lesson Four. See Table 3.

Processing Groups

Subjects in the No-Lookbacks Processing Group had higher TE efficiency scores than subjects in the Lookbacks [$F(1,161) = 3.60$, $p = .059$], Search [$F(1,161) = 3.64$, $p = .058$], and Read Only [$F(1,165) = 5.41$, $p = .021$] processing groups.

There were no differences or interactions on the TI efficiency scores by processing group for Lesson Four. See Table 3.

Time to Target

Time required to find answers to adjunct questions (time to target) was significantly less for subjects who read the text before reading questions than for subjects who read questions first and then searched for answers. For TE subjects, on Lesson One questions, $F(5,299) = 2.74$, $p < .02$. On Lesson Two questions, $F(5,299) = 6.16$, $p < .0001$. On Lesson Three questions, $F(5,299) = 5.27$, $p < .001$. For TI questions, $F(1,114) = 89.83$, $p < .00001$.

For TE subjects, there were significant processing group by questions in Lesson Two [$F(5,299) = 2.39$, $p = .038$] and processing group by Lesson Three [$F(5,299) = 3.83$, $p < .005$] interactions. This indicates that, within these two lessons, the difference between Lookbacks and Search times to target was greater for some questions than for other questions.

For questions in Lesson One, Search subjects with TE questions took 2.87 times as long as Lookbacks subjects to find the target paragraphs. For Lesson Two, Search subjects took 2.9 times as long. For Lesson Three, Search subjects took 3.89 times as long. Overall, Search subjects with TE questions took 3.22 times as long as Lookbacks subjects with TE questions.

For TI subjects, there was also a processing group by lesson interaction, indicating that the difference between Lookbacks and Search times to target was greater for one or more lesson than it was for the other(s).

On Lesson One, Search subjects with a TI question took 5.82 times as long as Lookbacks subjects with a TI question to find the target paragraph. On Lesson Two, Search subjects took 2.57 times as long. On

Lesson Three, Search subjects took 6.56 times as long. Overall, Search subjects with TI questions took 4.98 times as long as Lookbacks subjects with TI questions to find target paragraphs.

See Table 4 for a comparison of each question's mean time to target between Lookbacks and Search groups.

[Insert Table 4 about here.]

DISCUSSION

Strategy Selection

Previous research has not been very helpful when trying to predict which strategies students would select when given a choice of how to read to answer questions. Teachers from the two experimental schools expressed the belief that a large majority of the students in the Same-Time assignment condition would read simply to answer the questions. However, this was not the case. No more than half the students did this during any one lesson, although there did seem to be a minor trend in this direction from Lesson One to Lesson Three. A surprisingly large number of students read the text all the way through and then looked for answers in the text, possibly reflecting the way they had been taught to read in elementary school.

Direct Effect

As noted by earlier investigators (Anderson & Biddle, 1975), the direct effect of questions has been robust in most previous adjunct questions studies, and this one is no exception. All groups with questions significantly outperformed students without questions on direct learning. The Search and Lookbacks groups outperformed the No-Lookbacks group as well, suggesting that it is helpful to have the text in front of a reader while he or she is answering questions about textual information, and that it is more helpful to use the text while answering questions than it is to answer from memory. However, it is the indirect effect which has been the most controversial and it is this which we direct our attention to.

Indirect Effect

The indirect effect on learning shown for the NL group during Lessons Two and Three, significantly outperforming both the Search and Read Only groups, argues for an indirect backward review (Frase, 1967; Anderson & Biddle, 1975) explained as a result of a non-selective backward mental review triggered by the

post-questions. During this review, all information previously read and temporarily stored must be reviewed by the reader to decide which information was relevant to the question and which was not. This review results in better retention of both directly questioned material and material not questioned when compared to a read only or a search group. This effect is weakened when subjects look back in the text to find answers, and is non-existent when subjects search for answers without reading the text first.

The Lookbacks subjects significantly enhanced their memory for questioned material relative to that of No-Lookbacks subjects. Temporarily stored questioned material is apparently rendered more memorable by this intensive rereading specifically to answer a question about it, as evidenced by the advantage the Lookbacks subjects had over the No-Lookbacks on direct learning. They also seem to have had an advantage on indirect learning which approached statistical significance over Search and Read-Only subjects. It appears that any temporarily stored indirectly questioned information is not completely dumped by the Lookbacks subjects.

Subjects in the Search group, at the other extreme from the No-Lookbacks subjects, selectively attend only to material directly questioned and, apparently, deliberately ignore non-questioned material (the flip-side to selective attention is screening out non-essential stimuli), functioning like the pre-questions groups of earlier studies. The Search group's direct effect was significantly greater than that of the No-Lookbacks group, and conversely the indirect effect for the No-Lookbacks group was significantly greater than that of the Search Group.

These findings support the speculations of Gustafson and Toole (1970) and Duchastel and Nungester (1984) that, under ecologically realistic conditions, an indirect effect should not be expected. However, it might be that, in earlier studies, search subjects were not separated out from subjects who first read the text all the way through and then read for answers. Quite possibly, in these two earlier studies, subjects were encouraged by the circumstances of their assignment conditions to simply read relevant material in order to pass a test. Such task orientation can lead students to overfocus in favor of questioned material at the expense of all other textual material, as the search subjects did in this study.

Interestingly, subjects in the Lookbacks-Allowed assignment condition did outperform those in the Same-Time and Read-Only conditions on indirect learning. A revealing comparison can be made between the differences among the assignment conditions and the differences among the processing groups. Subjects in

the Lookbacks-Not-Allowed assignment condition did not significantly outperform those in the other conditions on indirect learning. However, the No-Lookbacks processing group, composed as it was of all students who did not look back in the text to answer questions, did significantly outperform the Search and Read-Only processing groups. The indirect effect for the Lookbacks-Allowed assignment condition, however, was significantly greater than it was for the Same-Time and Read-Only conditions.

Arguably, the No-lookbacks processing group was strengthened in its indirect effect by the inclusion of subjects from the Lookbacks-Allowed and Same-Time assignment conditions who in fact did not look back in the text. At the same time, the indirect effect for these two conditions would have been strengthened by the inclusion of these subjects who did not look back and thus reaped the benefits of the indirect backward review.

The difference between assignment group and actual processing group reported here might explain ambiguous findings from earlier research. Possibly the indirect effect for the lookback condition in previous studies was strengthened by the inclusion of subjects who selected themselves into a no-lookbacks processing group. Similarly, earlier studies that included a lookbacks-allowed condition might have had many students who read simply to prepare for a test as cued by study guide adjunct question. These subjects would correspond to the Search subjects of this study. Unfortunately, this cannot be confirmed, because previous studies did not (as far as a reader can judge) ascertain whether or not subjects did what they were supposed to do, but only that they worked within the limitations imposed on them, which often gave them considerable latitude. Sometimes, in fact, it is difficult to know exactly what subjects were allowed to do and/or the conditions under which they read.

In this study, the results showed that direct and indirect learning can be more directly attributed to processing group than to time spent reading. For example, the No-lookbacks group spent about the same amount of time reading the text as did the Read-only group. However, the No-lookbacks group was significantly superior to the Read-only group in both direct and indirect learning. This embarrasses any theory that attributes the effects of adjunct questions solely to the extra time spent reading to answer those questions.

Reading Efficiency

As Anderson and Biddle (1975); Reynolds and Anderson (1982) comment, "Time is cheap, achievement dear." It is not so much how much time one throws at a learning task which is important as it is how much learning one accomplishes per unit time; the next consideration might be how much time one can afford to spend in learning.

Results of this study suggest that if total learning is the only consideration, and the time it takes is of no consequence, then clearly the best procedure is that of the Lookbacks subjects. Read the entire text first, then read one's study guide or homework questions, then use the text to answer them. The Lookbacks had a strong advantage over all other processing groups but the Search group in direct learning, and learned considerably more indirectly than either the Search or the Read Only groups.

However, if one is short on available time for study, and can be reasonably certain that a significant portion of an upcoming criterion event will be drawn from a set of questions, then the Search techniques is definitely the more efficient. On both the TE efficiency and TI efficiency dependent measures the Search group performed significantly better than all the other groups. Bear in mind that the TE efficiency and TI efficiency measures are in the number of criterion items correct per second. So the fact that the mean for TE efficiency for the Search group was .0112/sec while it was .0077/sec for the Lookbacks group suggests that the Search subjects would answer .0035 more items correctly per second or .21 items correctly per minute of study time than would subjects in the Lookbacks group. This translates into an average advantage of approximately two correct items for every ten minutes of reading time for a Search subject over a Lookbacks subject.

If one is uncertain about how well study guide questions covers the material on the criterion event, then it would appear that the Lookbacks method of reading first, then reading to answer questions will help the student learn the most textual material. One thing appears certain: virtually any strategy of question usage is better than no questions at all, based on the performance of this Read Only group.

Indirect Forward Effects

Results from Lesson Four show that subjects who did not look back in the text to answer questions for Lesson Three did significantly better than all other groups on Lesson Four TE criterion items. The forward

effect is arguably attributable to the more careful attention to the text given by the No-Lookbacks subjects, a confirmation of earlier theorizing by Frase (1967) and Rickards (1979). These subjects had no reason not to expect adjunct questions at the end of Lesson Four, and they knew they could not look back. Lookbacks subjects might have expected questions, but would have expected access to the text again; hence, they could afford to read less carefully. Search subjects, receiving no questions with the text as they had for the first three lessons, might have concluded that they were in effect "done for the day," and didn't need to read the rest of the text very carefully. Furthermore, there were no differences in time spent by these groups, so any differences for Lesson Four learning must have been attributable to processing differences.

Implications for a Curriculum

One ventures into dangerous ground when speculating about how findings about observations taken under controlled experimental conditions translate into teaching practice. However, perhaps a few of these findings have relevance for the classroom.

Homework and Study Guides

The direct effect of such questions on learning, whether assigned as daily homework or given as a suggested study guide, seems virtually incontrovertible. Assignment of questions which cover information considered important can be expected to greatly facilitate the learning of that information.

Many parents and teachers will probably not be surprised to learn that students who read simply to answer a question will learn no more than the answer to that question. How should homework questions fit into classroom practice? The evidence seems to suggest that students who read the text first and then read to find answers to their questions will benefit directly and indirectly over students who have no such aid. One would hope that students answering questions as homework, or as a study guide, would avail themselves of the opportunity to consult the text, and that they read the text before answering them. The indirect effect for this group admittedly is a marginal one, but when total learning is considered, the read-first, then look-back-to-answer-questions strategy is the most productive.

Teachers, aware as they surely are that some students will study no more than answering questions on a study guide requires, can make one of two adjustments. One thing they can do is caution students that mere attention to study guide questions at the expense of all other textual information will only learn the answers

to those questions, and that, if tests cover more than that, students who only read to answer the questions will not be prepared for those tests. A second possible adjustment, of course, would be for teachers to begin to test only from the material covered by a study guide. The same caveat would apply to homework questions.

Regular Quizzes

Many teachers will be gratified and not surprised to know that quizzes directly following assigned readings have both a direct and indirect effect on learning. Lest we overextend our findings, it must be added that the above results refer to questions which directly followed reading. Such results might not be found under the circumstances of a 24-hour delayed quiz, which is of course closer to what the garden variety "pop quiz" resembles.

One possible adaptation would be to put students into study groups or cooperative learning groups. Have them attempt to predict test questions and set about answering them during class time. Then quiz the class on what they had been studying. The quiz itself could be expected to have both direct and indirect effects on the students' learning, even without the hypothetically beneficial effects of the study groups during class time.

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Table 1

Number of Students by Assignment Condition and Question Type in Each Processing Group, by Lesson

Chapter Lesson	Assignment Condition by Question Type by Processing Group									
	Lookbacks Allowed						Same Time			
	TE		TI		TE			TI		
	LB	NL	LB	NL	LB	NL	S	LB	NL	S
Lesson One	18	1	14	7	16	4	18	14	4	15
Lesson Two	16	1	16	5	14	6	19	15	3	16
Lesson Three	17	1	14	7	13	6	19	14	3	17

Note. Students in the Lookbacks (LB) processing group first read the text and then looked back in the text to answer questions. Students in the No-Lookbacks (NL) processing group read the text and then answered from memory without looking back. Students in the Search (S) processing group read the question first and then searched the text for answers.

Table 2

Group Means of Lessons Two and Three Criterion Question Performance by Assignment Condition and Processing Group

				Assignment Condition			
Lesson	Criterion Item Type	Effect Type	Adjunct Question Type	Lookbacks Not Allowed	Lookbacks Allowed	Same Time	Read Only
2 & 3	Repeated TE	Direct	TE	1.21	1.51	1.54	.66
2 & 3	New TE	Indirect	TE, TI	.87	.97	.71	.66
4	New TE	Indirect	TE, TI	2.78	2.28	2.20	2.11
				Processing Group			
				No Lookbacks	Lookbacks	Search	Read Only
2 & 3	Repeated TE	Direct	TE	1.21	1.64	1.48	.66
2 & 3	New TE	Indirect	TE,	.92	.85	.60	.66
2 & 3	Repeated TI	Direct	TE	2.18	1.67	1.10	2.16
2 & 3	New TI	Indirect	TI	2.17	2.74	2.87	2.16
4	New TE	Indirect Forward	TE, TI	2.86	2.15	1.99	2.11
4	New TI	Indirect Forward	TE, TI	2.68	2.26	1.91	2.56

Note: On repeated items, Read Only scores are shown for purposes of comparison only.

Table 3

Efficiency Score Means by Assignment Condition and Processing Group

Efficiency Score Type	Lesson	Assignment Condition: Lookbacks Not Allowed	Lookbacks Allowed	Same Time	Read Only
TE	2 & 3	.0075	.0086	.0096	.0055
TI	2	.0076	.0073	.0090	.0079
TE	4	.0133	.0122	.0113	.0094
TI	4	.0117	.0146	.0115	.0116

		Processing Group: No Lookbacks	Lookbacks	Search	Read Only
TE	2 & 3	.0085	.0077	.0112	.0055
TI	2	.0077	.0069	.0111	.0079
TE	4	.0140	.0114	.0100	.0094
TI	4	.0135	.0125	.0099	.0116

Table 4

Time Taken (in seconds) to Find Paragraph Containing Target Information After Reading Question by Question Number and Processing Group

Adjunct Question Number	Processing Group		Adjunct Question Number	Processing Group		Adjunct Question Number	Processing Group	
	Lookback	Search		Lookback	Search		Lookback	Search
TE Adjunct Questions								
1	17.7	79.4	7	83.9	137.1	13	27.5	156.3
2	55.5	128.2	8	49.7	182.5	14	17.4	144.5
3	25.2	56.0	9	20.5	114.5	15	11.9	38.3
4	13.4	113.5	10	17.3	31.5	16	14.8	26.7
5	19.3	30.2	11	23.3	57.6	17	21.1	52.3
6	22.9	56.0	12	33.2	103.3	18	19.1	33.9
Average by lesson:								
One	26.1	76.5	Two	34.8	100.9	Three	17.7	68.9
TI Adjunct Questions								
1	20.7	104.0	2	14.5	37.3	3	8.5	55.8
Average of all three lessons:								
	14.5	61.2						